H-Block Impact on Incumbent PCS Operations

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Executive Summary

This report analyzes the potential "mobile-to-mobile" interference cause by H-Block mobile devices transmitting in the 1915-1920 MHz band, to nearby incumbent PCS handsets operating in the PCS mobile receive band of 1930-1990 MHz. Included in this report is an extensive analysis and interpretation of the test data from the H-Block tests, which were performed by two test labs commissioned by the CTIA. The H-Block tests included Receiver Overload tests, Inter-modulation (IM) tests, out-of-band emissions susceptibility tests (AWGN tests), and out-of-band emissions (OOBE) measurements of incumbent PCS handsets. Eleven victim PCS handsets were tested operating on CDMA, GSM and UMTS technologies. Ten of the eleven handsets represent the popular handset models in the existing PCS systems.

By far, the worse interference was indicated in the IM tests with H-Block signals. In this case, the H-Block signals received as low as -36 dBm can interfere with incumbent PCS handsets operating on the B-Band, as indicated for half of the CDMA handsets tested. This represents the most severe interference case -- resulting in interference to incumbent PCS handsets at a distance of 8 meters, or 26 feet away from just one H-Block device transmitting at the +23 dBm limit. It is also possible that multiple H-Block devices may be transmitting within a range of 8 meters -- in these cases the H-Block signals can combine and further degrade incumbent PCS operations.

H-Block signals also have the potential to cause interference to incumbent PCS handsets operating on all PCS bands (A through F). In receiver overload tests, the results show interference occurs with a received H-Block signal of -28 dBm or greater, for two CDMA handsets and the UMTS handset tested. This is equivalent to a separation distance of 3.1 meters (or 10.3 feet) away from H-Block devices transmitting at the +23 dBm limit. In tests at higher temperatures, the results indicate that even more PCS handsets will experience interference.

To protect the integrity of PCS operations, the results of the IM tests -- showing the worst interference -- should be used to determine appropriate H-Block transmit power limits. To assess proper OOBE limits that will protect incumbent PCS operations the results of the AWGN and OOBE measurements should be used.

Based upon the test results, the following operating limits for H-Block mobile devices should be adopted, to protect incumbent PCS handsets operating at a distance of 1 meter away (assuming the 3 dB of body and other miscellaneous losses):

1. The output power limit for H Block mobile devices operating in the 1918.125-1920 MHz portion of the upper H Block spectrum should be +5 dBm;
2. The output power limit for H Block mobile devices operating in the 1916.875-1918.125 MHz portion of the middle H Block spectrum should be +8 dBm;
3. Further testing is needed to determine an appropriate power limit for the 1915-1916.875 MHz portion of the lower H Block spectrum. Initial analysis indicates this portion of spectrum should be limited to approximately +18 dBm.

4. The OOBE limit for H Block mobile devices should be -76 dBm/MHz, for OOBE in the 1930 to 1990 MHz bands (incumbent PCS mobile receive bands).

The OOBE limit of -76 dBm/MHz is consistent with industry standards and supported by the OOBE of incumbent PCS handsets that were tested. The OOBE of incumbent PCS handsets were measured to an average of -95.2 dBm/MHz for CDMA handsets, -97.4 dBm/MHz for the UMTS handset, and -77.7 dBm/MHz for GSM handsets. In addition, the AWGN test results indicate that an OOBE of -76 dBm/MHz is needed to protect existing PCS handsets at a distance of 1 meter away, assuming 3 dB for body and miscellaneous losses. In AWGN tests, half the CDMA handsets tested showed interference occurring at the -117 dBm in-band nose level, which corresponds to the -76 dBm/MHz OOBE level (compute as -76 dBm – 3 dB obstruction losses – 38 dB for 1 meter separation = -117 dBm/MHz). In addition, as indicated by Agilent in this proceeding, H-Block devices can effectively employ transmit filters to comply with the -76 dBm/MHz limit.

The transmit power limits of +5 and +8 dBm are substantially lower than typical PCS mobile operations. Accordingly, this limits the suitability of the middle to upper portions of the H-Block spectrum to operations such as non-conventional, low-power mobile operations (e.g. indoor micro-cells, or asymmetrical data service); fixed point-to-point operations; or air-to-ground operations.

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1 Introduction

V-COMM has prepared this report in response to the FCC's request for comments regarding the potential interference to existing PCS operations from the PCS H Block allocation.[1] In preparation for this report, V-COMM has reviewed documents submitted in the FCC record and reviewed the FCC's Notice of Proposed Rulemaking (*NPRM*) regarding service rules for the proposed PCS H Block allocation.[2] V-COMM has also conducted PCS H Block interference tests, and reviewed the test results from two independent test laboratories that performed PCS H Block testing, pursuant to CTIA test plans and submitted by the CTIA in this proceeding.

This report addresses the potential for "mobile to mobile" interference resulting from PCS H Block mobile phones transmitting in 1915-1920 MHz band, and causing interference to incumbent PCS mobile phone receivers' operating in the 1930-1990 MHz band. This report is intended to address the potential impact to existing PCS subscriber units operating with CDMA technology. Although this report primarily addresses the impacts to victim CDMA phones, other phones show similar characteristics. This report includes an overview of the H Block testing performed, an engineering interpretation of the test results, an overview of the impact to PCS operations, and the proposed FCC operating limits for the PCS H Block allocation.

As an initial matter, it should be noted that the type of interference that can be caused an H block handset operating in close proximity to an existing PCS handset is "one-way" interference only. This is due to the spectrum allocation of the PCS H Block with respect to the incumbent PCS bands (A-F Bands), and only 10 MHz of separation between the PCS H Block mobile transmit band and the incumbent PCS mobile receive band. In this case, incumbent PCS mobile subscribers can experience interference from H Block handsets, *while H block mobiles do not experience any interference from PCS A-F Band mobiles*.

This represents an area of concern for incumbent PCS providers because the new H Block provider may not have an incentive or interest in addressing the interference it may cause to tens of millions of subscriber units that operate in PCS spectrum today.[3] Therefore, the FCC must set appropriate operating limits to protect the integrity of existing PCS operations.

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[1] V-COMM, L.L.C, is a wireless telecommunications consulting company with principal members having over 20 years experience in the wireless industry. We have provided our expertise to wireless operators in RF engineering, system design, implementation, performance, optimization, and evaluation of new wireless technologies. We have extensive industry experience in all CMRS technologies. V-COMM's company information and experiences are highlighted in this report's Appendix A, along with biographies of senior members of its engineering team.

[2] *Service Rules for Advanced Wireless Services in the 1915-1920 MHz, 1995-2000 MHz, 2020-2025 MHz, and 2175-2180 MHz bands*, WT Docket 04-356, Notice of Proposed Rulemaking (*NPRM*), released September 9, 2004.

[3] This is a different situation than exists today for the PCS industry. In this industry the interference has always been a two-way interference issue, where either party can experience the interference. In this case, the interference is self-regulating, with both parties having the incentive to correct the interference

There are three (3) sources of interference that can occur from H Block mobiles to the existing base of PCS subscriber units.

1. **Out-of-Band Emissions (OOBE)** -- The first source of interference is due to the OOBE from the H block mobile transmitter that extends into the 1930 to 1990 MHz (incumbent PCS mobile receive spectrum). These emissions can raise the noise floor in the PCS mobile receive band, and desensitize nearby PCS subscriber's units. These emissions cannot be filtered at the victim receiver because they are received in-band to the receiver.

2. **Receiver Overload --** The second source of interference results in receiver overload at the incumbent PCS subscriber units**.** In this case, the emissions from the H Block mobile transmitters in the 1915-1920 MHz band can cause receiver overload and/or receiver desensitization to nearby incumbent PCS subscribers units. This type of interference can occur from nearby PCS H Block signals because they are attenuated by the victim mobile receiver's filter by as little as 3 to 8 dB, as compared to standard PCS mobile signals that are attenuated by 50 to 60 dB.[4] Consequently incumbent PCS phones will receive H Block signals up to 50 dB stronger than signals from standard PCS phones. This represents a receiver overload and desensitization problem for the incumbent PCS phones, which are not designed to accept this level of interference. This type of interference can impact PCS phones operating on any frequency in the PCS spectrum bands (PCS Bands A-F).

3. **Inter-modulation (IM)** -- The third source of interference results in IM products that are generated within the incumbent PCS phone's receive system, which are caused by the mixing of strong H Block signals and the incumbent's transmitting signal. In this case, the IM products are received on-channel, in the receive band of the incumbent PCS phone's receiver. Again, in this case, the H Block signals are received at much stronger levels (up to 50 dB) than standard PCS signals, and results in IM interference to incumbent PCS subscriber units. This type of interference has the potential to impact PCS phones operating on PCS Bands B, F and C.[5]

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and develop appropriate operating standards (i.e. out-of-band emissions) that provide sufficient protection from interference to either parties' operations. H Block providers would not have the same incentive and, for competitive reasons, may actually *prefer* to cause interference to the embedded base of subscribers, which only improves chances of increasing its subscriber base.

[4] See Sprint's exparte, filed on September 1, 2004, showing the PCS Duplexer Rx Response to H-block Interferers (All Temps) on page 35.

[5] IM interference from H Block signals and standard PCS phones have the potential to impact and be received on-channel in the PCS B, F and C bands, and cannot cause IM interference to PCS A, D or E bands. The frequency of the IM product depends on the mathematical relationship as follows: 3rd Order IM products (2F2-F1 & 2F1-F2) can impact mobiles operating on PCS B Band; 5th Order IM products (3F2-2F1 & 3F1-3F2) can impact mobiles operating on PCS F Band; 7th and 9th Order IM products (4F2-3F1 & 4F1-3F2; 5F2-4F1 & 5F1-4F2) can impact mobiles operating on PCS C Band.

To prevent these three (3) types of interference from occurring, the FCC must set appropriate technical operating limits for the H Block mobile devices, which include limits for out-of-band emission in the 1930 to 1990 MHz band, and transmit power limits for emissions in the 1915 to 1920 MHz band. Based upon the test results, the service limits proposed in the NPRM will not sufficiently protect the embedded base of PCS subscriber units.

Comprehensive testing with standard PCS phones was performed to determine the severity of interference from H Block signals, and to assist the FCC in determining appropriate H Block service rules that will protect incumbent PCS subscriber units.

2 Overview of H Block Testing

In this section, V-COMM provides an overview of the H Block testing performed by two independent test laboratories pursuant to CTIA Test Plans. The test laboratories were contracted by the CTIA, and the test results were submitted by CTIA in this proceeding. The two labs are PCTEST Labs ("PCTEST")[6] and Wireless Network Laboratory of Rutgers University ("WINLAB").[7]

2.1 Test Overview

H Block testing was performed pursuant to CTIA Test Plans, [8] and according to test procedures that were developed to measure the potential interference from H Block signals to incumbent PCS phones. Throughout the testing, the impairment or degradation in voice quality for various standard PCS mobile devices under test (DUT) was measured for a range of input H Block signal levels. These tests include Receiver Overload tests, IM Tests, Additive White Gaussian Noise (AWGN) or In-Band Noise Tests, and OOBE Tests.

A variety of typical PCS subscriber phones were tested by PCTEST and WINLAB. These phones consist of popular model handsets that are made by the major manufacturers in the market today, and are current models that are being sold in phone stores today. These phones represent the subscriber units that will be in circulation for the longest amount of time (3 or more years), and provide a good cross section of the embedded base of PCS phones that exist today.[9] The PCS handsets included in the CTIA tests were models operating with the wireless

[6] PCTEST is located in Columbia, MD, and was founded by former FCC Laboratory engineers to assist industry in regulatory technical matters. PCTEST is Telecommunications Certification Body authorized to approve various types of devices subject to certification under the FCC's Rules, and holds a number of accreditations, including A2LA, ANSI, NVLAP and NMI. *See* http://www.pctestlab.com.

[7] WINLAB is an industry/university cooperative research center focused on wireless technology, founded at Rutgers University in New Jersey.

[8] CTIA's Test Plan has been submitted in this FCC proceeding.

[9] Other phone models are expected to have similar chipsets and components, and are expected to have similar performance with respect to H Block interference.

technologies CDMA, GSM and UMTS. A total of 11 PCS handsets were included consisting of 6 CDMA handsets, 4 GSM handsets, and 1 UMTS Handset.[10]

The testing used test setups and parameters appropriate for simulating H Block signals. Tests include simulated H Block CDMA and GSM signals as the interferer on upper and middle H Block channels using standard offsets from the band edge. For example, the "Upper H Block" CDMA Interferer used a center frequency of 1918.75 MHz, using the standard PCS CDMA offset of 612.5 kHz from the upper band edge, and the "Middle H Block" center frequency was 1917.5 MHz. For the "Upper H Block" GSM Interferer, the center frequency was 1919.8 MHz, which uses the GSM standard 100 kHz offset from the upper band edge.

The testing also used test setups and parameters appropriate for simulating typical PCS network operating conditions. Base station emulators were used to establish calls to the PCS phones under test. Test parameters were consistent with industry standard parameters for CDMA2000 3G-1X voice calls, and measured the FER over 5000 frames (100 seconds). To simulate real-world PCS network operating conditions for the victim subscriber phone under test, test parameters were used to establish a target baseline FER that is representative of typical network operating conditions for the two calls levels used in the tests.

In the test setup for Receiver Overload and IM tests, an H Block band pass filter was used to attenuate the side band emissions of the signal generator that was emulating H Block signals. This filter provided more than 100 dB of isolation in the 1930 to 1990 MHz band. This ensures the impact to the victim mobile is a result of receiver overload and/or IM, and not a result of the signal generator's OOBE. In the test setup for measuring the OOBE of standard PCS handsets, sufficient filtering and attenuation is needed for the handset's transmit signal in the 1850 to 1910 MHz band. For example, in the WINLAB test setup two pass band filters were used to attenuate the emissions in the 1850-1910 MHz band by greater than 90 dB. With this level of filtering, the handset transmit signal it will not overdrive the low-noise-amplifier, and allows accurate measurement of the handset's OOBE in the 1930 to 1990 MHz range. In addition, the tests were performed in an RF shielded environment to isolate the device under test from any unwanted signals in the surrounding environment.

Two call levels were used to serve the victim PCS phones during tests. For the victim CDMA phones tested, the two call levels were -100 dBm, and -105 dBm. Serving calls at these levels are an essential part of service that customers have come to need and expect, and the PCS networks reliably served customers to these levels with very sensitive subscriber units and very low operating noise conditions occurring in market. At these signal levels, PCS networks

[10] PCTEST Lab tested 4 PCS handsets (2 CDMA handsets, 2 GSM handsets), and WINLAB tested 7 handsets (4 CDMA handsets, 2 GSM handsets, 1 UMTS handset). These handsets were selected by the carriers as representative of the majority of phones on their networks. The models passed the carrier's internal certification & testing, and met their standards for use on their networks. Any given handset may perform above or below the results for these sample phones.

provide acceptable call quality and reliability to subscriber units. These levels are 5 to 10 dB above the actual sensitivity performance of CDMA phones, which is typically -110 dBm.[11]

These low signal call levels occur frequently in a variety of locations, and not just at the edge of service. These locations include in-buildings, in-vehicles, in trains, in buses, in airplanes (grounded), and in the outer regions of the cell coverage areas in rural and suburban markets. Low signal levels are particularly common in-buildings, where building structure can attenuate signals by 10 to 30 dB. For example, with outdoor signals of -85 dBm, the building attenuation of 15 dB will decrease the received signal at the PCS phone to -100 dBm inside the building.[12] And, an outdoor signal of -90 dBm and a vehicle penetration loss of 10 dB will reduce the signal to -100 dBm at the phone.[13] At these -100 dBm received signal areas, the performance of the call is still in the excellent quality range, and typically has an FER of about 1%. Another case is an outdoor signal of -90 dBm and a building penetration loss of 15 dB that reduces the received signal level at the phones inside the building to -105 dBm. The received signal level of -105 dBm occurs in CDMA networks with acceptable call quality, and typically has an FER of about 5%.

The -105 dBm level also represents a **faded signal condition** from a mean received signal level of -100 dBm. Remember that in real-world situations the received signal level at a mobile phone is not static. It undergoes frequent fading (i.e. multi-path, Raleigh, log-normal, etc) consistent with the environment, and varies over distances proportionate to the wavelength of the signal, which is 6 inches for PCS frequencies. A typical fade margin for PCS systems is approximately 5 dB, which occurs about 34% of the time for calls indoors.[14] This means that a call received at an average level of -100 dBm will be fading to -105 dBm at least 34% of the time. This is a considerable amount of time (i.e. 1 out of every 3 seconds), and it will occur continuously throughout the call. If the call is interfered with during these fading conditions,

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[11] The TIA minimum performance standard for receive sensitivity of CDMA phones is -104 dBm with a FER of 0.5%, which is considered in the excellent audio quality range of 0 to 1% FER. However, the *actual* receive sensitivity performance of CDMA phones is typically -110 dBm.

[12] ITU Guidelines For Evaluating Radio Transmission Technologies for IMT-2000 (document ITU-R M.1225, section 1.1.2) specifies the average building penetration loss is 12 dB, with a standard deviation of 8 dB. The first standard deviation of penetration losses extends to 20 dB.

[13] The penetration loss of vehicles is about 5 to 10 dB, depending on the location of the handset in the car. When using a headset, the location of the handset will often be below the window level, and in which case will experience more attenuation. For buses, trains, and airplanes the penetration losses will be about 10 to 20 dB, depending on the size of the windows, location of the handset, and type of materials involved.

[14] A 5 dB fade will occur 34% of the time (equivalent to cell edge reliability of 66%) for indoor locations. Industry standards (e.g. ITU standards) specify Log-normal shadow fading with a standard deviation of 10 dB for outdoor locations, and 12 dB for indoor locations. Hence, received signal levels will fade by 5 dB 34% of the time for indoor locations, and 31% for outdoor locations.

then this amount of interference (34% of time) can be very annoying to PCS phone user, and cause them to end calls.[15]

The FER performance of the mobile devices under test was recorded for H Block signals increasing in 1 dB increments. A baseline FER level was used for each test setup, to represent the FER performance that occurs in typical network operating conditions. For the -100 dBm call level, the initial FER of the mobile device was between 0.75 to 1%, and for the -105 dBm level the initial FER was in the 4.5 to 5% range.

The voice quality of a CDMA call is related to the FER performance of the call. The FER is the error rate of voice frames received during the CDMA call. Based upon V-COMM's extensive experience with testing CDMA networks, the approximate relationship of voice quality to FER is given in the table below. As indicated below, the call level of -100 dBm at 0.75 to 1% FER meets industry standards and is in the very good voice quality range, and the faded call level of -105 dBm level at 4.5 to 5% FER is in the acceptable voice quality range.[16] Above the 5% FER level, the quality of the CDMA call deteriorates to the point it becomes unusable, with medium to substantial degradation (audio severely distorted, unintelligible and/or completely muted) to dropped calls.

Table 1 CDMA FER to Voice Quality

CDMA FER	Voice Quality	Typical for PCS Calls at Receive Levels
0% to 2%	Industry Standard (Very Good)	-100 dBm
2% to 5%	Acceptable	-105 dBm
Above 5%	Medium to Substantial Degradation, to Dropped Calls	(Unacceptable)

3 Interpretation of Test Results

In this section, we examine the results of the H Block tests and outline the impact to incumbent PCS subscribers at the proposed OOBE and transmit power limits specified in the NPRM. These tests include Receiver Overload, IM, AWGN, and OOBE measurements. All tests were performed with victim CDMA handsets at the received signal level of -100 dBm and -105 dBm, both at ambient room temperature and an elevated temperature, [17] to observe the impact of H Block signals upon incumbent PCS handsets.

[15] If interference disturbs or degrades a call when it's fading (i.e. 34% of the time, or 1 out of every 3 seconds) this is sufficient to annoy users and cause repeated obstructions of service throughout a call. Also, in this case it can be reasonably expected that the victim user will terminated the call.

[16] PCS CDMA networks are generally designed for 1% to 2% FER levels, with occasional excursions slightly above that level that are considered acceptable.

[17] Tests were performed at two temperature levels; at ambient room temperature, and an elevated temperature of approx. 40° C (approx. 100 degrees F).

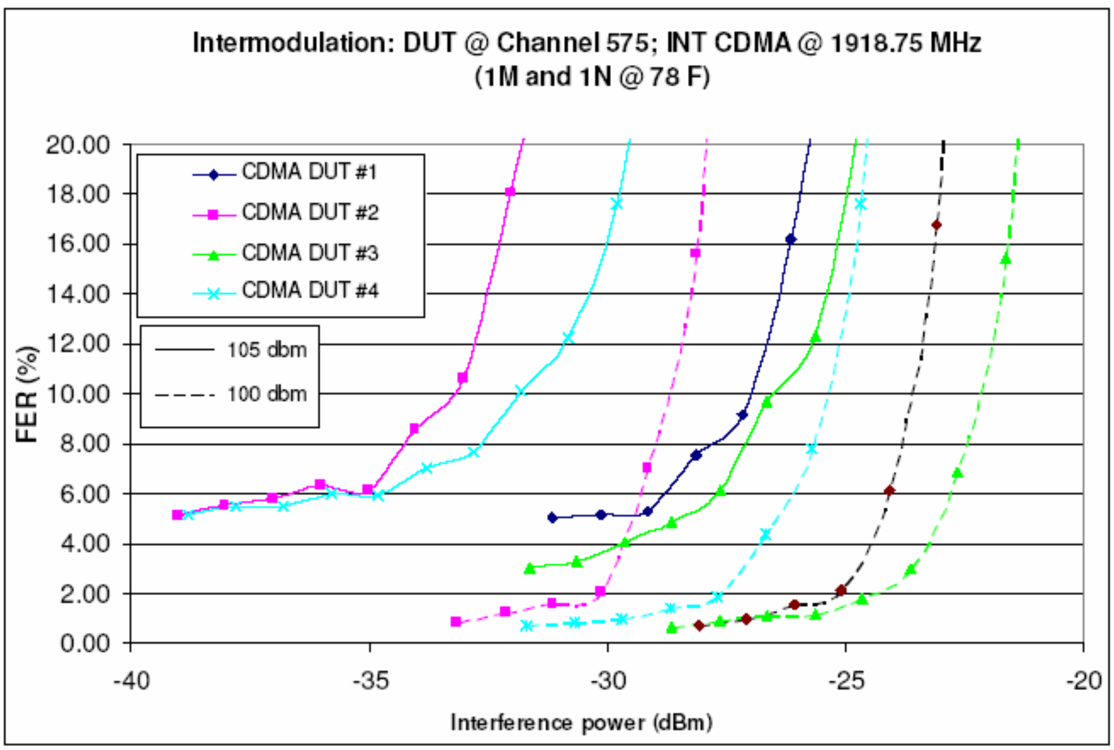
When analyzing the test data, the point of noticeable interference occurs when the victim CDMA call experiences a 1% FER *increase*, or 1% FER degradation in voice quality, as compared to the initial FER level.[18] Therefore, for the tests at -100 dBm call level the interference occurs at the 2% FER level (in effect this doubles the FER from 1% to 2%), and at -105 dBm call level the interference occurs at the 6% FER level. These FER levels are summarized in the table below.

Table 2 Criteria of Interference Occurs at 1% Degradation in FER

Call Level	Baseline FER	Interference Occurs at FER Level
-100 dBm	0.75% to 1%	2% or above
-105 dBm	4.5% to 5%	6% or above

Increasing the interference above these levels results in FER levels that increase quickly (as the call quality deteriorates further) until the call is dropped. For example, see the WINLAB test results below where the FER levels increasing very rapidly with small increases in interference levels.

Figure 1 Sample WINLAB Test Results for PCS CDMA DUT



[18] This assumes that the incumbent PCS subscribers are accepting a voice quality degradation of 1% above the typical levels that would normally occur with no H block interference.

3.1 Antenna Gains, Path Losses and Separation Distances

In the sections below, the typical PCS mobile antenna gain, the path losses associated with the head and body of PCS phone users, and the mobile-to-mobile separation distances associated each H Block interference level is provided (using the propagation loss at 1900 MHz).

3.1.1 PCS Handset Antenna Gains

The industry standard for PCS handset antenna gains is 0 dBi. This figure represents the antenna gain value that is used in almost all vendor link budgets, and it is specified in industry standard documents for mobile antenna gains.[19] Also, the standard PCS mobile antenna is representative of a quarter-wave length isotropic antenna, which is equivalent to a 0 dBi antenna gain.

The 0 dBi antenna gain value is also conservative, and in many cases the actual antenna gain will exceed this value by 1 to 3 dB. See the table below for the antenna gains of the PCS handsets used in the CTIA tests.[20]

Table 3

PCS Handsets Tested in CTIA H-Block Tests	Service Provider	Handset TX Power Output (dBm)	Radiated TX Power (EIRP dBm)	Antenna Gain (dBi)
PCTEST Sample A (CDMA)	Sprint	25.0	26.0	1.0
PCTEST Sample B (CDMA)	Sprint	25.2	24.9	-0.4
PCTEST Sample C (GSM)	T-Mobile	30.0	32.3	2.3
PCTEST Sample D (GSM)	T-Mobile	29.6	29.4	-0.2
WINLAB CDMA #1	Sprint	24.7	25.8	1.1
WINLAB CDMA #2	VZW	24.9	27.6	2.7
WINLAB CDMA #3	VZW	24.0	25.3	1.3
WINLAB CDMA #4	Sprint	23.5	25.9	2.4
WINLAB GSM #1	Cingular	30.0	30.5	0.5
WINLAB GSM #2	AWS	30.4	30.1	-0.3
WINLAB UMTS	AWS	21.2	23.8	2.7

Average Antenna Gain (dBi) = 1.2

[19] Industry Standards reference the PCS mobile antenna gain at 0 dBi. These include the TIA, 3GPP and ITU Standards documentation.

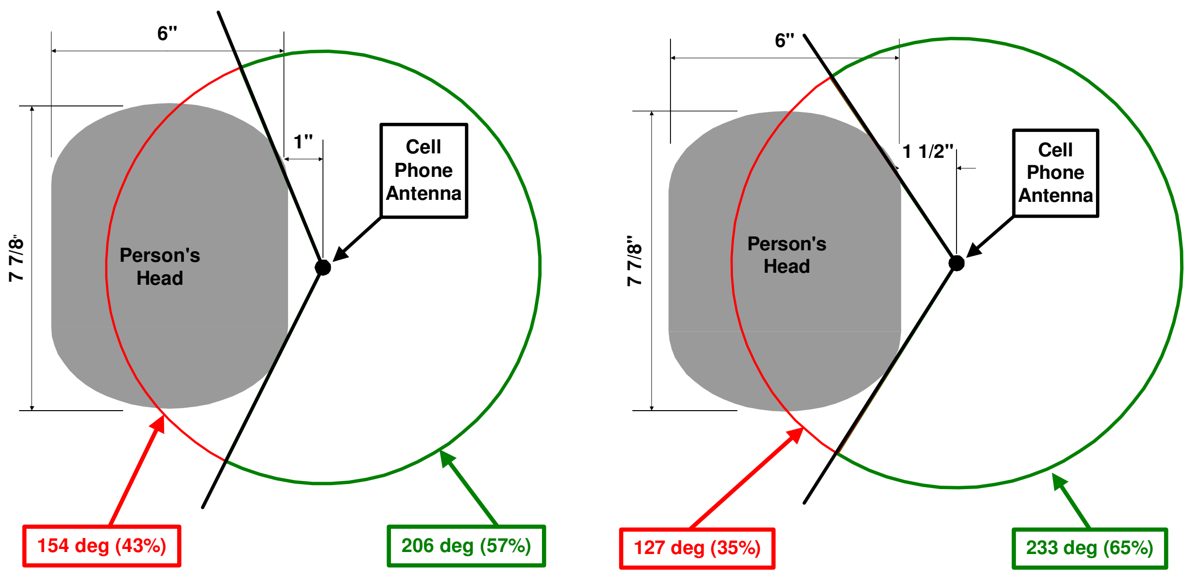
[20] Based upon the phone type certification report for Part 24 emissions (available at www.fcc.gov), the antenna gain values of the PCS handsets included in CTIA's tests measured as low as -0.4 dBi to as high as +2.7 dBi. These results cover transmit PCS frequencies, and the receive PCS frequencies are expected to exhibit similar characteristics. These results use the radiated power measurements (in dBm EIRP) minus the output power measurements (in dBm) at the phone's antenna RF port, which yield the PCS handsets' antenna gain.

The average antenna gain of the phones tested in the CTIA tests measured to +1.2 dBi. For these reasons, the PCS handset antenna gain of 0 dBi is used in these analyses, and is considered a conservative value that is 2.7 dB lower than the worse case.

3.1.2 Obstruction Losses for Phone User's Head and Body

An analysis of the link budget between two mobiles also needs to consider the losses between the two mobile users. In general, for the majority of the time the head or body of the user will not obstruct the signal path, when a person is using his or her phone. This is illustrated in the figure below, where the signal path is unobstructed for 57% to 65% of the time, for mobile phone antennas held 1 inch to 1.5 inches away from a person's head.[21]

Figure 2 Unobstructed Signal Paths for PCS Phone Users (Top View)



The above diagrams show the areas of unobstructed views in green, and area of obstructed views in the red part of the circle above. The case on the left is for a PCS phone antenna that is 1 inch from a person's head, which is a common for PCS phones that are non-folding types. For PCS phones that are clam-shell types, the antenna is removed approximately 0.5 inches farther away, and the antenna is usually 1.5 inches from a person's head (pictured on right diagram). The more popular type of PCS phone today is the clam-shell folding type. This type of PCS phone will have unobstructed signal paths about 2/3 of the time (or 65% of time, as shown above), which is for the majority of the time. In addition, if we consider signal path reflections from various environments (e.g. inside a train or bus), these reflections can also

[21] This exhibit is drawn to scale. The dimensions utilized are consistent with the MIL Standard 1472D for an average male head size, which is 6 inches wide by 7 7/8 inches in length.

contribute to signals received by users in other directions as well, even in the direction of the obstruction (red areas shown above), which can results in signals as strong as ones from unobstructed views. For these reason, it is appropriate to consider no obstructions (or 0 dB head/body loss) in some cases, when analyzing the impact of nearby H Block devices. However, for the analyses in this report, a much more conservative head/body loss factor will be assumed, which is a total of 3 dB for head/body and other miscellaneous losses. This value includes the “average” signal in all directions around a phone user, including the directions that are obstructed by a person’s head or body.

These head/body loss values can average 1 to 3 dB loss (e.g. 1 dB of head/body loss is consistent with 3GPP standards), however for this report the more conservative value of 3 dB for head/body loss and other miscellaneous losses is used.

3.1.3 Separation Distances and Path Losses for H-Block Devices

The path loss at 1900 MHz and separation distances for typical PCS handsets are given in the table below, for H Block mobile devices transmitting at the proposed transmit power limit of +23 dBm, as specified in the NPRM. These values include a loss of 3 dB for head/body losses and other miscellaneous losses.

Table 4 Path Loss and Separation Distances for H Block Interferer Levels

H Block Interferer Received at Victim PCS Phone (dBm)	Equivalent Path Loss (dB)	Separation Distance (feet)	Separation Distance (Meters)	Separation Distance to Victim PCS Phones
-8	28	1.0	0.3	<--- 1 foot
-9	29	1.2	0.4	
-10	30	1.3	0.4	
-11	31	1.5	0.4	
-12	32	1.6	0.5	<--- 0.5 meter
-13	33	1.8	0.6	
-14	34	2.1	0.6	<--- 2 feet
-15	35	2.3	0.7	
-16	36	2.6	0.8	
-17	37	2.9	0.9	
-18	38	3.3	1.0	<--- 1 meter
-19	39	3.7	1.1	
-20	40	4.1	1.3	
-21	41	4.6	1.4	
-22	42	5.2	1.6	
-23	43	5.8	1.8	
-24	44	6.5	2.0	<--- 2 meters
-25	45	7.3	2.2	
-26	46	8.2	2.5	
-27	47	9.2	2.8	
-28	48	10.3	3.1	<--- 3 meters
-29	49	11.6	3.5	
-30	50	13.0	4.0	<--- 4 meters

-31	51	14.6	4.4	
-32	52	16.4	5.0	<--- 5 meters
-33	53	18.4	5.6	
-34	54	20.6	6.3	
-35	55	23.1	7.0	<--- 7 meters
-36	56	25.9	7.9	
-37	57	29.1	8.9	
-38	58	32.7	10.0	<--- 10 meters
-39	59	36.6	11.2	
-40	60	41.1	12.5	
-41	61	46.1	14.1	<--- 14 meters

For example, receiving an H Block interference level of -18 dBm is equivalent to a path loss of 38 dB at 1900 MHz, and a separation distance of 1 meter between the H Block mobile device and the victim PCS phone. Also, receiving an H Block interference level of -12 dBm is equivalent to a path loss of 32 dB at 1900 MHz, and a separation distance of 0.5 meters. These path losses and distances (from the above table) will be used in the following sections of this report, in the analysis of the various levels of H Block interference that impacts incumbent PCS phones.

3.2 Receiver Overload Tests

Receiver overload tests were performed to determine the impact of H Block signals to typical PCS handsets operating in the PCS spectrum bands. These test results will assist in determining appropriate *transmit power limits* for H Block mobile devices to protect incumbent PCS phones.

A summary of the Receiver Overload Tests performed for the CDMA victim handsets, along with the purpose of each test, is given in the table below.

Table 5 Receiver Overload Tests

Interferer	Victim Rx Channel & PCS Band	Purpose of Test
Upper H Block CDMA @ 1918.75	25 / A-Band	Shows impact to PCS A band, from an Upper H Block CDMA interferer.
Upper H Block CDMA @ 1918.75	450 / B-Band	Shows impact to PCS B band, from an Upper H Block CDMA interferer.
Upper H Block GSM @ 1919.8	25 / A-Band	Shows impact to PCS A band, from an Upper H Block GSM interferer.
Middle H Block CDMA @ 1917.5	25 / A-Band	Shows impact to PCS A band, from a Middle H Block CDMA interferer.
PCS C Band CDMA @ 1908.75	25 / A-Band	Confirms there is no interference from an upper channel in the PCS C Band.

The Receiver Overload test results indicate that H Block signals can cause interference to incumbent PCS phones. The extent of the interference depends on the separation distance between the H Block device and the incumbent victim phones. At closer distances and stronger interference levels, the H Block signals cause severe interference to victim PCS phones, to the point where the audio quality of the audio call of the voice call is severely distorted, muted, and/or dropped.

These test results confirm that the FCC proposed transmit power limit of +23 dBm is not sufficient to protect incumbent PCS operations. In many cases, this transmit power limit will result in interference to a variety of incumbent PCS handsets in variety of typical situations. In Section 4.2 of this report, an analysis is given to determine the H Block transmit power limit required to protect the integrity of PCS operations.

Based upon these test results, H Block signals can be expected to impact all PCS spectrum bands (A through F), and potentially affect tens of millions of PCS subscriber units in the market today.

The table below summarizes the Receiver Overload test results reported by PCTEST and WINLAB, for an upper H Block CDMA interferer to CDMA and UMTS handsets operating in PCS A Band.

Table 6 Summary of Receiver Overload Test Results for an Upper H-Block Interferer

PCS Receive Level (dBm)	**Temp.**	**Received H Block Interference (in dBm) that Results in 1% Increase in FER Rate**						
		PCTEST DUT A	**PCTEST DUT B**	**WINLAB DUT 1**	**WINLAB DUT 2**	**WINLAB DUT 3**	**WINLAB DUT 4**	**WINLAB UMTS**
-100	19° C	-14	-22	-18	-21	-19	-18	-16
-100	40° C	-16	-22	-19	-22	-22	-18	-19
-105	19° C	-22	**-28**	-26	-26	**-28**	-26	-27
-105	40° C	-22	-28	-31	-31	-28	-28	-36

Observations of the Receiver Overload test results are as follows:

1. Upper H Block Impact to PCS A-Band -- An upper H Block interferer causes the worst interference to victim handsets operating in the PCS A Band, which is the lowest band in PCS spectrum. For example, the WINLAB test results show interference occurs with a received H Block signal of -28 dBm, as received at the victim CDMA handset DUT #3, at -28 dBm at victim CDMA handset PCTEST DUT B, and at -27 to -30 dBm for the victim UMTS handset. These results were derived with an upper H Block interferer, a victim call at the lowest channel in the PCS A-Band at the -105 dBm receive call level, and at ambient temperature level. The results at the elevated temperature were worse than the ambient by 1 to 5 dB, and the results at a static receive level of -100 dBm were better by 5 to 9 dB. The -105 dBm call level represents the faded condition of a call operating at a mean signal level of -100 dBm. Interference occurring at a received level of -28 dBm represents a

separation distance of 3.1 meters away (or 10.3 feet) from an H Block device transmitting at the +23 dBm power level, assuming 3 dB for head, body and miscellaneous losses.

The H-Block transmit power limit of +23 dBm will not protect victim PCS phones. An H-Block phone transmitting at this level results in a received signal of -18 dBm at victim PCS handsets 1 meter away, assuming 3 dB for head, body and miscellaneous losses, which will cause extremely severe interference to PCS handsets. For example, at the received interference level of -18 dBm, the PCTEST DUT B victim CDMA call operating at a signal level of -100 dBm will experience a FER of approx. 100%, and drop the call. Also, for the WINLAB's CDMA DUT #2, the PCS call will experience a FER of 10% on average for a call level of -100 dBm, and when fading -105 dBm (occurs 34% of the time) the FER will reach between 30 to 50% FER. At this level of H-Block interference, PCS calls 1 meter away will be either have their calls dropped or experience completely muted audio due to very high FER levels.

2. Upper H Block Impact to PCS B-Band -- An upper H Block interferer causes interference to other PCS bands, and not just the PCS A-Band. The test results for the victim phones in the center of the PCS spectrum (B-Band channel 450) confirms that receiver overload also impacts other PCS bands. The results for the victim phone on channel 450 show comparable results, within a couple of dB, to the results for the A-Band victim phones. In some cases, the receiver overload impact to the B-Band was the same (i.e. WINLAB CDMA DUT3 at -100 dBm call level), some cases 2 dB worse (i.e. PCTEST DUT A at -105 dBm call level), in other cases better by 2 dB (i.e. WINLAB CDMA DUT 1 & 4 at -100 dBm call level). Based upon these test results, H Block interference is expected to impact all PCS spectrum bands (A through F).

3. Upper H Block GSM Interferer -- An upper H Block interferer using GSM technology causes about the same level of interference as an upper H Block interferer using CDMA technology. These results are within a couple dB of each other, with some cases more severe for the CDMA interferer, and other cases the GSM interferer is slightly worse. For example, for PCTEST DUT A the GSM H-Block interferer was worse by 1 dB at -100 and -105 dBm call levels, and for WINLAB DUT 1 through 4 the GSM H-Block interferer was 1 to 2 dB less severe, at -105 dBm call level. For the UMTS victim handset, the GSM interferer was 1 to 3 dB worse than the CDMA interferer.

4. Middle H Block Impact to PCS A-Band -- A middle H Block interferer also causes interference to incumbent PCS handsets, albeit to a lesser degree than an upper H Block interferer. Test results show that a middle H Block interferer at 1917.5 MHz causes about 3 dB less interference on average than an upper H Block interferer. For example, the WINLAB DUT 1 & 3 results shows the impact is 2 dB less severe at the -105 dBm call level than the upper H Block interferer case, it's the same for DUT 2 & 4 at the -105 dBm call level, its 7 to 10 dB less severe for PCTEST DUT A& B, and its 1 to 3 dB less severe for WINLAB DUT 1 through 4 at the -100 dBm call level. The test results for WINLAB show that a middle H Block signal at -26 dBm causes interference to WINLAB DUT 2, 3 & 4 when at the -105 dBm call level, at ambient room temperature.

   Test results for the middle H Block interferer confirms that a transmit power limit of +23 dBm for middle H Block signals will not protect incumbent PCS phones from interference. Based upon these test results, a lower transmit power limit is required for middle H Block emissions, and it should be approximately 3 dB higher than the limit for upper H Block emissions.

5. Impact from PCS C-Band Signals -- The receiver overload test with a PCS C-Band interferer showed that existing handsets do not interfere with each other. In the worst case for these tests, for victim CDMA phone DUT B in PCTEST tests at -105 dBm call level, the interference did not occur until a received signal level of +7 dBm. This is equivalent to a separation distance of 4 inches, and allows existing handsets to operate at this close distance. Other CDMA handsets performed even better that this, and allow existing mobiles to operate at even closer distances. For example, in the WINLAB tests, all CDMA handsets show interference-free operation with existing C-band signals received as high as +12 dBm (2 inches) at both temperatures and call levels.

6. Impact During Fading Conditions to -105 dBm Call Level -- Receiver overload tests performed with the call level at -105 dBm shows more sensitivity to H Block signals, than calls operating at the static receive level of -100 dBm level. Most of the test results show interference occurs about 3 to 10 dB less severe at a static receive call level of -100 dBm. The -105 dBm call level showed more susceptibility to interference, as was expected for calls operating at these levels with lower signal margins.[22] At these low call levels, H Block signals can cause the greatest and most severe interference to victim CDMA handsets. The -105 dBm call level represents the faded condition of a call operating at a mean signal level of -100 dBm. This faded condition can be expected to occur 34% of the time (or 1 out of every 3 seconds) during the call that is operating at a mean signal of -100 dBm. Even in cases where the interference doesn't cause the call to be dropped by the handset, this amount of interference (34% of the time) could be reasonably be expected to cause users to terminate the call.

7. Impacts at Higher Temperatures -- Tests at the elevated temperature (approx. 100 degrees F) showed more sensitivity to H Block signals, in general. Most phones showed interference is worse at an elevated temperature by approximately 1 to 5 dB as compared to phones operating at ambient room temperature. The high temperature test results should also be considered by the Commission, as the outdoor temperature can increase to these levels on hot summer days, and in many southern states.

[22] CDMA phones can operate with good voice quality to very low signal levels (even below the noise floor) with high processing gains inherent in CDMA technology. The -105 dBm level is about 4 to 5 dB above the actual sensitivity performance of these CDMA phones. In addition, in soft handoffs regions, CDMA phones can achieve a gain of approx. 3 dB with its RAKE receiver combining multiple input signals, which further improves the receive sensitivity of CDMA phones in these situations. However, the CDMA handset's RAKE receiver cannot overcome nearby sources of interference.

3.3 Inter-modulation Tests

IM tests were performed to determine the impact of H Block signals to typical PCS handsets. These test results will assist in determining appropriate *transmit power limits* for H Block mobile devices to protect incumbent PCS phones.

A summary of IM Tests performed for the CDMA victim handsets, along with the purpose of each test, is given in the table below.

Table 7 IM Tests

Interferer	Victim Rx Channel & PCS Band	Purpose of Test
Upper H Block CDMA @ 1918.75	575 / B-Band	Shows 3rd Order IM impact to PCS B band, from an Upper H Block interferer.
Middle H Block CDMA @ 1917.5	550 / B-Band	Shows 3rd Order IM impact to PCS B band, from a Middle H Block interferer.
Upper H Block CDMA @ 1918.75	840 / F-Band	Shows 5th Order IM impact to PCS F band, from an Upper H Block interferer.

The IM test results indicate that H Block signals can cause severe interference to incumbent PCS phones. The IM interference caused by H Block signals is much worse than the receiver overload interference, and will cause interference to incumbent mobiles at farther distances away. The extent of the interference also depends on the separation distance between the H-Block device and the incumbent victim phones. Even at distances much farther than 1 meter, H-Block signals can cause severe interference to victim PCS phones, resulting voice quality that is severely distorted, muted, and/or result in dropped calls.

These test results confirm that the FCC proposed transmit power limit of +23 dBm is too high a limit to protect incumbent PCS operations. In many cases, this transmit power limit will result in severe interference to incumbent PCS handsets in variety of typical situations, and as far as 12.5 meters away. In Section 4.2 of this report, an analysis is given to determine the H Block transmit power limit required to protect the integrity of PCS operations.

Based upon these test results, H Block signals can be expected to cause IM interference to victim PCS handsets operating in PCS spectrum bands B and F,[23] potentially impacting millions of PCS subscriber units in the market today.

The table below summarizes the IM test results reported by PCTEST and WINLAB, for upper and middle H Block interferers to CDMA handsets operating on channels 575 and 550 in the PCS B Band.

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[23] IM interference from 3rd order products has the potential to interfere with PCS B-Band channels in the center 5 MHz of the PCS B-Band (1/3 of the PCS B-Band). IM interference from 5th order products have the potential to impact the PCS F Band (5 MHz).

Table 8 Summary of IM Test Results for an Upper H-Block Interferer

PCS Receive Level (dBm)	Temp.	Received Upper H Block Interference (in dBm) that Results in 1% Increase in FER Rate					
		PCTEST DUT A	PCTEST DUT B	WINLAB DUT 1	WINLAB DUT 2	WINLAB DUT 3	WINLAB DUT 4
-100	19° C	-25	-32	-24	-29	-23	-27
-100	40° C	-28	-36	-26	-32	-24	-28
-105	19° C	-24	**-40**	-29	**-36**	-28	**-36**
-105	40° C	-32	-41	-30	-39	-32	-34

Table 9 Summary of IM Test Results for a Middle H-Block Interferer

PCS Receive Level (dBm)	Temp.	Received Middle H Block Interference (in dBm) that Results in 1% Increase in FER Rate					
		PCTEST DUT A	PCTEST DUT B	WINLAB DUT 1	WINLAB DUT 2	WINLAB DUT 3	WINLAB DUT 4
-100	19° C	-18	-31	-23	-26	-21	-25
-100	40° C	-21	-35	-26	-30	-22	-26
-105	19° C	-21	-38	-30	-32	-26	-32
-105	40° C	-25	-41	-32	-38	-32	-34

Observations of the IM test results are as follows:

1. IM Causes the Worst Interference -- IM interference from H Block signals will cause the worst interference to victim PCS handsets of the three types of interference that can occur (e.g. receiver overload, IM and OOBE). The IM interference occurs at lower receive levels, or about 6 to 10 dB lower, as compared to the receiver overload test results for the CDMA handsets. Consequently, this represents the most difficult compatibility issue for H Block devices to co-exist with existing PCS handsets. Therefore, these IM test results should be used to determine the appropriate H Block transmit power limits to protect existing PCS handsets.

2. Upper H Block IM Impact to PCS B-Band -- In the worst case with an upper H Block interferer, the IM causes interference to the PCS handset within 12.5 meters (41 feet) of an H Block device transmitting at the FCC limit of +23 dBm.[24] This result occurred for the PCTEST DUT B at the call level of -105 dBm at ambient room temperature, showing IM interference occurring at the -40 dBm level. In WINLAB's tests, two CDMA phones (DUT 2 & 4) showed IM interference occurring at -36 dBm in the same test. The -36 dBm level is equivalent to separation distance of 8 meters (26 feet).[25] At these very large separation

[24] H Block mobile devices can transmit at +23 dBm if they are newer data or VOIP technologies that utilize data rate control, rather than transmitter power control, to control emissions.

[25] This represents the distance from an H Block device transmitting at the +23 dBm power level, assuming 3 dB for head, body and other miscellaneous losses.

distances, the H-Block devices have the potential to cause IM interference to multiple PCS handsets operating, even to handsets having obstructed views (i.e. handsets operating in adjacent rooms).

The IM test results at the elevated temperature showed worse even impacts than the ambient test results by 1 to 8 dB, and the results at a static receive level of -100 dBm were better by 1 to 9 dB. The -105 dBm call level represents the faded condition of a call that is operating at an average signal level of -100 dBm. This faded condition can be expected to occur 34% of the time (or 1 out of every 3 seconds) during the call. Even in cases when the interference doesn't drop the call, this amount of interference (34% of the time) will cause users to be annoyed and calls to be disrupted, to the point where users will certainly terminate the call.

Hence, the H-Block transmit power limit of +23 dBm will not protect victim PCS phones. At this transmit level, H-Block phones will be received signal at -18 dBm at victim PCS handsets 1 meter away, assuming 3 dB for head, body and miscellaneous losses. At this level, all CDMA handsets dropped their calls in the IM tests with an upper H Block signal. For the middle H Block IM tests, 4 out of 6 CDMA handsets dropped their calls at this level, with the other 2 handsets showing severe interference at this level of H-Block interference.[26]

3. Middle H Block IM Impact to PCS B-Band -- A middle H Block interferer also causes IM interference to incumbent PCS handsets, albeit to a lesser degree than an upper H Block interferer. Test results show that a middle H Block interferer at 1917.5 MHz causes about 3 dB less on average (or in the range of 1 to 7 dB less severe) IM interference than an upper H Block interferer. For example, the WINLAB CDMA DUT 1, 2, 3 & 4 showed the IM impact is 1 to 3 dB less severe for a middle H Block interferer at the call level of -100 dBm, and 1 to 6 dB less severe for a call at -105 dBm, at ambient room temperature. Also, PCTEST DUT A showed 7 dB less impact, and DUT B showed 1 dB less impact at the -100 dBm call level, for a middle H Block interferer.

   IM interference from a middle H Block signal showed interference occurs at the level of -32 dBm for WINLAB DUT 2 & 4, and at -38 dBm for PCTEST DUT B, for tests at ambient and call level of -105 dBm. These interference levels are equivalent to separation distances of 5 meters and 10 meters, respectively, away from a middle H-Block signal transmitting at the +23 dBm power limit. These separation distances are very large considering the proximity of people using PCS phones in crowded situations.

4. 5th Order IM Impact to PCS F-Band -- IM interference with H Block signals can also impact the victim handsets operating on the PCS F-Band, with 5th order IM products received on-channel in the PCS F-Band. WINLAB performed a sample test on the CDMA handset DUT #2 operating in the PCS F-Band on channel 840. These results indicate that H Block signals can cause IM interference to the PCS F-Band (5th order IM product), in addition to the PCS B-Band (3rd Order IM product).[27] These results indicate that IM

[26] For example, WINLAB CDMA DUT 3 shows the FER is an average of 75% at -100 dBm call level, and reaches 100% FER every 3 seconds during fades to -105 dBm.

[27] In addition, IM interference can potentially impact incumbent phones operating in the PCS C-Band however this case was not tested (it was not included in the CTIA Test Plan). The 7th and 9th order IM

interference occurs to PCS F-Band victim phones at received levels that are about 11 dB above the levels that impact PCS B-Band phones. As expected, the 3rd order IM is the strongest and worst interference case, but the 5th order can also cause interference at 1 meter.[28]

5. Impacts at Higher Temperatures -- Tests at the elevated temperature (approx. 100 degrees F) showed more sensitivity to H Block signals, in general. Most phones showed worse IM interference at an elevated temperature, by approximately 1 to 8 dB (or an average of about 3 to 4 dB) as compared to phones operating at ambient room temperature. The high temperature test results should also be considered by the Commission, as the outdoor temperature can increase to these levels on hot summer days, and in many southern states.

3.4 AWGN Tests (Performed to Determine H-Block OOBE Susceptibility)

Additive White Gaussian Noise (AWGN) tests were performed to determine the in-band noise that interferes with typical PCS handsets. These tests were performed to determine suitable *OOBE limits* for H Block mobile devices that would protect incumbent PCS phones.

A summary of the AWGN Tests performed for the CDMA victim handsets, along with the purpose of the test, is given in the table below.

Table 10 AWGN Tests

Interferer	Victim Rx Channel & PCS Band	Purpose of Test
AWGN Interferer on PCS A-Band (1930 -1945 MHz)	25 / A-Band	Show AWGN level that impacts typical PCS handsets. Use to assess OOBE limits for H Block mobile devices.

The AWGN test results indicate that in-band noise levels have the potential to cause interference to typical PCS handsets. The extent of the interference depends on the OOBE levels of the interfering device and the separation distance to the victim PCS phones. CDMA handsets were shown to be sensitive to in-band noise levels occurring at very low levels (in the mobile receive band from 1930 to 1990 MHz). Therefore, the OOBE levels of nearby transmitting H Block mobile devices can potentially cause severe interference to victim CDMA phones, to the point where the audio quality of the PCS call is severely distorted and/or completely muted.

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products associated with an H Block signal have the potential to be received on-channel to a PCS C-Band victim phone, although these impacts are expected to be less severe than the 3rd and 5th orders, because the 7th and 9th order IM products are generally weaker signal strengths than 3rd and 5th orders.

[28] Based on the 5th Order IM test results, at 1 meter separation with 3 dB for head, body and other losses, a received interference level of -18 dBm causes a 1% increase in the FER of a call at -100 dBm, and this level of interference the FER increases to 15% during fades to the -105 dBm level.

These test results confirm that the FCC proposed OOBE limit of -60 to -66 dBm/MHz is not sufficient to protect incumbent PCS handsets from the OOBE of H Block devices. In many cases, this OOBE limit will result in interference to a variety of incumbent PCS handsets, in all PCS spectrum bands (A through F), and in variety of typical situations. In Section 4.3 of this report, an analysis is given to determine the H Block OOBE limit required to protect existing PCS handsets from experiencing interference.

The AWGN tests show that CDMA handsets will experience interference at an in-band noise level of -110 dBm/MHz, for the CDMA handset tests with the call level at -100 dBm.[29] During a faded call to -105 dBm level, the in-band noise causes interference to CDMA handsets at the -117 to -118 dBm/MHz AWGN level. This occurred to WINLAB's CDMA DUT 2, 3 & 4. This is the most sensitive case (at -105 dBm call level)[30] when the call has less signal margin to overcome the in-band noise occurring. Nearby interfering sources that have OOBE in the 1930 to 1990 MHz band, will increase the noise levels received by victim CDMA handsets, and have the potential to cause dropped calls and interference to calls operating at these levels.

The AWGN test results indicate that an OOBE limit for H Block devices at -76 dBm/MHz for OOBE in the 1930 to 1990 MHz spectrum (PCS mobile receive bands),[31] is needed to protect incumbent CDMA phones operating at a distance of 1 meter away. This is 10 dB below the proposed OOBE limits in the NPRM. With an OOBE of -66 dBm/MHz existing PCS handsets within 1 meter of an H Block device will receive in-band noise levels at -107 dBm (this assumes 3 dB for head, body and miscellaneous losses), which is 10 dB stronger than the point where interference is shown to occur. At the in-band noise level of -107 dBm/MHz CDMA handsets show a 3% increase in FER on average, and during fades will experience FER increased to 50%. This has the potential to disrupt all PCS handsets within 1 meter, to severely degrade the voice quality of calls, and to annoy the existing PCS subscribers to the point they terminate the call.

Based upon AWGN test results, the in-band noise causes interference to CDMA calls at -117 dBm/MHz (3 out of 4 CDMA phones showed interference occurring at this level in WINLAB tests; DUT 2, 3 & 4), therefore the OOBE limit for the H Block devices should be set at -76 dBm/MHz to protect mobiles 1 meter away (assumes 3 dB for head, body and miscellaneous losses).[32] This OOBE limit is also consistent with TIA IS-98 mobile standards, which states that the OOBE in the 1930 to 1990 MHz range (mobile PCS receive band), must be below -76

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[29] WINLAB tests show that AWGN interference at -100 dBm/MHz causes interference to CDMA DUT 2 & 3, for the ambient temperature test at -100 dBm call level.

[30] The actual receive sensitivity of typical CDMA handsets is -110 dBm. This is about 6 dB below the TIA minimum receive sensitivity standard for CDMA phones, which is -104 dBm for the 3G-1X vo-coder. Receive sensitivity is specified at the FER of 0.5%, which is in the excellent audio quality range.

[31] Compliance with this OOBE limit should utilize a RMS average detector, and perform measurements referenced to the device's RF connector. These procedures are consistent with the test procedures used in the CTIA tests.

[32] Computed as -76 dBm/MHz – 38 dB for 1 meter – 3 dB head/body loss = -117 dBm/MHz at the victim.

dBm/MHz. This OOBE limit is required for H Block devices to protect incumbent CDMA phones operating at a distance of 1 meter away.

3.5 OOBE Measurements of Typical PCS Handsets

The OOBE of typical PCS handsets were measured to confirm these handsets meet TIA/EIA standards[33], which is less than -76 dBm/MHz in the 1930 to 1990 MHz mobile receive band. These test results, along with the AWGN test results, confirm that the OOBE of typical PCS handsets do not impact incumbent PCS phones.

The OOBE of typical handsets transmitting in the PCS A, B and C bands were measured at the lowest assigned receive channel in the PCS mobile receive spectrum (e.g. channel 25 having a center frequency of 1931.25 MHz). Measurements were performed at the RF connector on the PCS handsets, with test equipment employing an RMS average detector, and the results were recorded in units of dBm/MHz. In these tests, the PCS handsets (DUT) were transmitted at their maximum transmit power levels, and at 10 dB below maximum power in a subsequent test. Measurements were performed at ambient room temperature and an elevated temperature of approximately 100 degrees F. A summary of the OOBE tests of typical PCS handsets is given in the table below.

Table 11 OOBE Measurements of Typical PCS Handsets

DUT Transmitter Band & Channel	Measure OOBE in Mobile Rx Band	Purpose of Test
PCS A Band / Chan 275	PCS A-Band / Chan 25	Measure OOBE of typical handsets operating in PCS A Band.
PCS B Band / Chan 600	PCS A-Band / Chan 25	Measure OOBE of typical handsets operating in the middle of the PCS spectrum.
PCS C Band / Chan 1175	PCS A-Band / Chan 25	Measure OOBE of typical handsets operating at the highest channel in PCS spectrum.

The results of the OOBE measurements of typical PCS handsets indicate that all CDMA and UMTS phones exhibited OOBE in the mobile receive PCS A-band in the range of -92 to -98 dBm/MHz. At these OOBE levels, existing CDMA & UMTS handsets can co-exist at a distance of 4 to 5 inches apart without causing interference to each other, even when transmitting at the maximum power level. The average OOBE of CDMA handsets in the PCS mobile receive band is -95.2 dBm/MHz, and for the UMTS phone it is -97.4 dBm/MHz

All of the CDMA and UMTS phones meet the TIA IS-98 OOBE limit of -76 dBm/MHz, and the average OOBE is below this limit by 19 to 21 dB. These test results confirm that existing PCS handsets' OOBE do not cause interference to each other, even at very close distances.

[33] TIA Standard IS98-E specifies handset radiated OOBE must be less than -76 dBm/MHz in the 1930-1990 MHz range.

The results of the OOBE measurements for the higher power GSM handsets exhibited OOBE in the mobile receive PCS A-band in the range of -71 to -81 dBm//MHz. The average OOBE of the GSM handsets is -77.7 dBm/MHz. The OOBE measurements of all GSM phones meet the -76 dBm/MHz OOBE level, with only two exceptions.[34] GSM handsets generally exhibit higher OOBE than CDMA & UMTS phones because GSM phones transmit at 7 dB higher levels, or +30 dBm EIRP rather than +23 dBm. However, even at the higher transmit power of + 30 dBm, most of the GSM handset measurements showed they meet the OOBE level of -76 dBm/MHz, and would not interfere with existing PCS handsets.

The OOBE measurements with PCS handsets transmitting at 10 dB below maximum power show that the OOBE reduced by up to 8 dB (as compared to maximum transmit power), with some tests showing the OOBE reducing to the noise floor of the test instrument, which was -93 dBm/MHz for PCTEST and -97.4 dBm/MHz for WINLAB's tests.[35] In addition, the OOBE results at the higher temperature showed about the same results as the ambient temperature case, and were within +/- 1 dB of the ambient room temperature results.

These OOBE results of existing handsets indicate that the limit of -76 dBm/MHz is appropriate for H Block devices. Existing PCS handsets that operate at the +23 dBm transmit power level comply with this limit by a large margin; or by about 20 dB on average, or by 16 dB in the worst case. Also, the -76 dBm/MHz OOBE level is an industry standard OOBE limit, and is required to protect existing CDMA handsets from interference at a distance of 1 meter away. In addition, in its ex-parte filing in this proceeding, Agilent stated that "it can produce a narrow-band duplexer covering G & H blocks that would allow a handset to meet -76 dBm OOBE as per TIA-98-F." For these reasons, the OOBE limit of -76 dBm/MHz is appropriate for PCS H-Block mobile devices.

4 Proposed Technical Limits for H Block Devices

In this section, we analyze the test results to determine the H-Block transmit power and OOBE limits necessary to protect incumbent PCS operations from experiencing interference. We also look at a variety of common situations where mobile phone subscribers use their phones, and assess the typical minimum separation distances between handsets operating in close proximity. A minimum separation distance is necessary to compute the OOBE and transmit power limits, along with the test results.

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[34] The two exceptions are: 1.) the WINLAB GSM DUT 2 at the highest C-Band channel at maximum power of + 30 dBm had an OOBE of -71 dBm/MHz; and 2.) PCTEST GSM DUT E at the highest C-Band channel at maximum power of +30 dBm had an OOBE of -72 dBm/MHz.

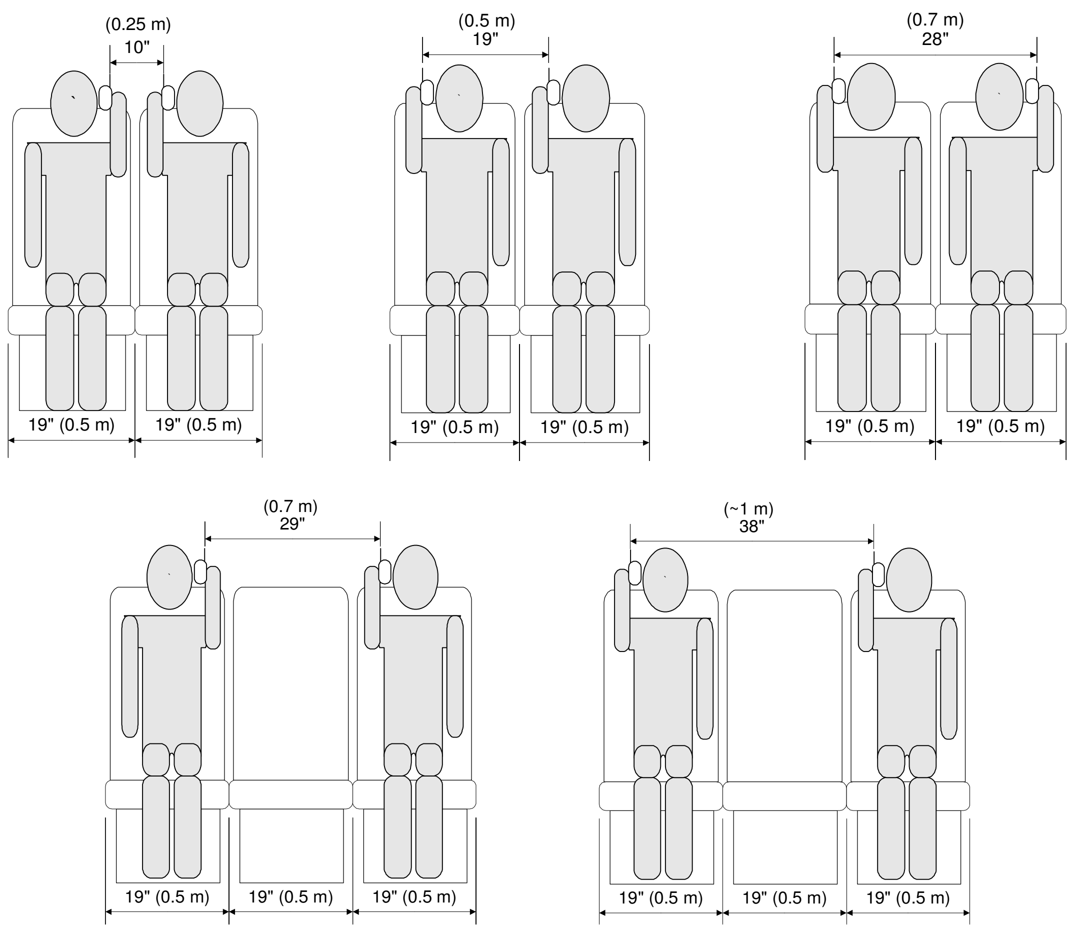
[35] The OOBE measurements reported by the test labs are referenced to the PCS handset's antenna terminal. Measurement settings employ a resolution bandwidth of 1 MHz, an RMS average detector, and the center frequency of lowest assigned channel in the PCS A-band (i.e. 1931.25 MHz for CDMA).

4.1 Typical Minimum Separation Distances

PCS phones are used in a variety of locations when people are at close distances apart. These locations are primarily when users are inside building or vehicles. The in-building locations include: at conferences, at the office, train stations, airport terminals, stadiums, arenas, movie theatres, doctor's waiting rooms, restaurant lobbies, and bus stations. The in-vehicle locations include inside trains, buses, airplanes on the ground, and automobiles. PCS phone users have gotten used to using their phones where and when their needs require them to, and this includes in crowded locations with other PCS phone users.

To analyze the typical minimum separation distance between PCS phone users, we considered a variety of typical locations. In these locations, the typical minimum separation distance between PCS phone antennas was within the range of 1 foot to 1 meter. For example, see the diagram below for separation distances between two PCS phone users that are sitting in a waiting area at the airport, at a conference room, or on a train.

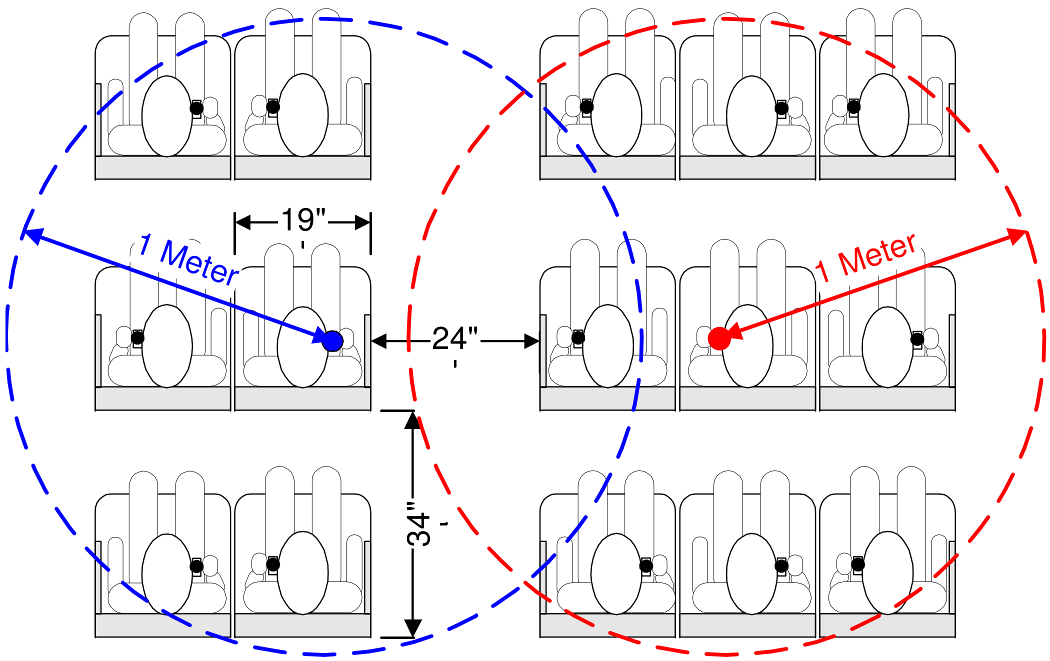
Figure 3 Minimum Separation Distances between PCS Phone Users



In these examples, the separation distances between PCS phones when users are sitting adjacent to or one seat over are 10 inches to 1 meter apart. These examples are typical, and use an average seat width of about 0.5 meters.[36] The average case is about 0.5 meters apart between PCS phone antennas.

The longest distance in these cases above is 1 meter. At one meter, many PCS phone users can be expected to be within this range. For example, see the illustration below of typical seating on a commuter or regional train.

Figure 4 One Meter Separation Distance



In these cases, the 1 meter separation represents an area with 6 or 8 victim PCS phone users are within range of an H-Block device, as shown above in the red and blue circled areas. Likewise, this also highlights the issue that multiple H-Block devices can impact one victim user. Assuming that half the devices above are operating on the H-Block, an existing PCS user in the center of the circles can receive interference from three to four H-Block devices simultaneously.[37]

These illustrations demonstrate that the 1 meter separation is a very conservative minimum, and in many cases phones will be closer than this distance. In addition, it should be noted that the 0.5 meter separation distance will occur in a variety of typical situations as well.

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[36] The average seat width of 0.5 meters (19 to 20 inches) is used in these diagrams. Airplane seats will be closer, or about 17 inches apart. Commuter train seats are about 18-19 inches apart, regional trains about 19 inches apart, and telephone booths about 24 inches apart. These seat dimensions for trains were measured on various commuter and regional trains on the Amtrak Northeast Extension corridor. The seat dimensions for airplanes were obtained from the web site www.seatguru.com. The diagram above is drawn to scale, using an average male head size centered in the seat.

[37] This increases the received interference level by 5 to 6 dB, as compared to the case when only 1 H-block device is transmitting within 1 meter of a victim PCS handset.

The 1 meter separation distance is used in the analysis below to determine the H-Block transmit power and OOBE limits that will protect existing PCS operations from experiencing interference. In addition, a total of 3 dB is assumed for losses associated with the head/body of the user and other miscellaneous losses.

4.2 Transmit Power Limits for H-Block Devices

The NPRM proposes a transmit power limit of +23 dBm for H-Block mobile devices. The receiver overload and IM test results show severe interference is caused to a variety of PCS handsets, and results in PCS calls that are severely degraded, muted and/or dropped.

Based on IM test results with an H-Block interferer in the upper portion of the band (1918.125 to 1920 MHz),[38] the transmit power limit of + 5 dBm is need to protect existing handsets from experiencing interference.[39] This is based upon CDMA handsets showing IM interference with an upper H-Block signal received at -36 dBm.[40] This assumes 1 meter separation exists between users, 3 dB of additional path loss over line-of-sight propagation is present, and at room temperature. At closer distances, higher temperatures, or when there are no obstructions from users' heads, existing PCS handsets will experience even worse interference at this transmit power level.

For middle H-Block emissions within 1916.875 to 1918.125 MHz, with test results showing interference is approximately 3 dB less severe than upper H-Block tests, a transmit limit of +8 dBm should apply to this portion of the band to protect existing PCS handsets. The middle H-Block range is from 1916.875 to 1918.125 MHz, using the standard channel assignments for 1.25 MHz carriers in PCS spectrum.

CTIA test plans did not include tests with lower H-Block emissions in the 1915 to 1916.875 MHz range. Therefore, the transmit power limits for the lower H-Block signals will need to be measured to determine a suitable limit that will prevent interference to existing PCS handsets. However, in absence of test data with lower H-Block signals, at this time we can analyze the receive filter performance of PCS handsets from measurements performed by Nokia Test Labs.[41] About 10 dB of additional rejection is observed in these measurements, as compared to

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[38] The transmit power limit applied to upper H-Block emissions (in the upper portion of the band) is from 1918.125 to 1920 MHz. This assumes the industry standard guard band of 612.5 kHz at the top of the H-Block, for signals with a carrier bandwidth of 1.25 MHz.

[39] The IM tests showed the most sensitivity to H-Block signals, therefore these tests are used to determine the H-Block transmit power limits, to prevent existing PCS handsets from experience interference.

[40] These results use the faded call level of -105 dBm, at room temperature. Several CDMA phones showed these results, and the worse phone showed an impact even 4 dB worse, at -40 dBm. The transmit power computation is +5 dBm EIRP, minus 3 dB for head/body loss, minus 38 dB for 1 meter separation, equals -36 dBm at the victim PCS handset.

[41] See Sprint's H-Block filing in this FCC proceeding, on pages 33-35, for measurements performed by Nokia Test Labs and reported for five receive duplexers utilizing SAW technology. These filters show

the rejection of the middle of the H-Block spectrum. Using this 10 dB figure as an initial value to estimate the rejection of the lower H-Block signals, and using the test results for middle H-Block signals, suggests a lower H-Block transmit power limit of +18 dBm is needed to protect existing PCS handsets, for H-Block emissions in 1915 to 1916.875 MHz. (This is 10 dB above the transmit power limit for the middle H-Block, which is +8 dBm.) However, before adopting this limit for the lower third of the H-Block spectrum, tests with lower H-Block signals should be performed to confirm PCS handset receive susceptibility to lower H-Block signals.

If an H-Block provider utilizes a wide-band technology that is 5 MHz wide (i.e. UMTS) then the upper transmit power limit of +5 dBm would apply to the entire H-Block for this case. If a 1.25 MHz carrier is used, then the limits specified above apply. These are based upon the test results using signals at these frequency assignments. Narrow-band interferers were not tested at all the possible frequencies within the PCS H transmit band however it can be expected that the results would be similar to the CDMA interferer cases, which were included. Therefore, the same limits for the upper and middle H-Block emissions should apply to narrow band technologies in the PCS H mobile transmit band.

These transmit power limits are for H-Block mobile devices. Other H-Block devices that do not generally operate within 1 meter of existing PCS handsets would not be required to meet these limits. For example, other uses of this spectrum can be fixed services (i.e. point-to-point for backhaul), or air-to-ground services. These services do not require such transmit power limits.

The transmit power limits of +5 dBm for upper H-Block emissions, and +8 dBm for the middle H-Block, represent much lower reverse-link power budgets than conventional PCS systems. For this reason, these portions of the band would probably be used differently. For example, H-Block can be used for fixed services or air-ground services at higher power levels. Also, H-Block can be used for wireless systems with smaller cell sizes, or indoor micro-cell or wireless PBX deployments that require less reverse link power. In addition, H-Block can be used to provider asymmetrical data service, with faster data service on the forward link, and much slower bandwidth speeds on the reverse link. Also, the reverse link performance can be improved to an extent with cell sites using smart antennas, or higher gain antennas, or tower-top pre-amps at the base stations for improved uplink performance to compensate for the lower mobile transmit power. Lastly, H-Block could be used to provide mobile service to users closer to the cell sites, and then handoff to higher power channels in the lower H-Block or to another spectrum band, for users needing more reverse link budgets and are further away from cell site or indoors.

4.3 OOBE Limits for H-Block Devices

The NPRM-proposed an H-Block OOBE limit of -60 to -66 dBm/MHz in the PCS mobile receive band from 1930 to 1990 MHz. The AWGN test results show that unacceptable interference can occur at this OOBE limit to a variety of incumbent PCS handsets, in all PCS

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additional rejection for the lower third of the H-Block, as compared to the middle B-Block spectrum, by about 10 dB (as interpolated off the graphs).

spectrum bands (A through F), and in variety of typical situations. For example, at the -66 dBm/MHz existing PCS handsets within 1 meter of an H Block device will receive in-band noise levels at -107 dBm (this assumes 3 dB loss for head/body loss, and other miscellaneous losses), which is 10 dB stronger than the point where interference is shown to occur. At the in-band noise level of -107 dBm/MHz CDMA handsets show a 3% increase in FER on average, and during fades will experience FER increased to 50%. This has the potential to disrupt all PCS handsets within 1 meter, to severely degrade the voice quality of calls, and to annoy the existing PCS subscribers to the point they terminate the call.

Based upon AWGN test results the OOBE limit for H Block devices should be less than -76 dBm/MHz for OOBE in the PCS mobile receive band (1930 to 1990 MHz),[42] to protect incumbent CDMA phones operating at a distance of 1 meter away. This limit is 10 dB below the proposed OOBE limits in the NPRM. The AWGN tests show that CDMA handsets will experience interference at the -117 to -118 dBm/MHz level. This occurred to WINLAB's CDMA DUT 2, 3 & 4, for the -105 dBm call level tests, which represents the faded condition of a call operating at an average level of -100 dBm. At this level the call has less signal margin to overcome the in-band noise occurring. Nearby interfering sources that have OOBE in the 1930 to 1990 MHz band, will increase the noise levels received by victim CDMA handsets, and have the potential to cause dropped calls and interference to calls operating at these levels.

Using the -117 dBm/MHz results (3 out of 4 CDMA phones at WINLAB showed interference at this level), the OOBE limit for the H Block devices should be set at -76 dBm/MHz to protect mobiles 1 meter away.[43] This OOBE limit is also consistent with TIA IS-98 mobile standards, which states that the OOBE in the 1930 to 1990 MHz range (mobile PCS receive band) must be below -76 dBm/MHz. This OOBE limit is required for H Block devices to protect incumbent CDMA phones operating at the separation distance of 1 meter apart.[44]

The OOBE limit of -76 dBm/MHz is appropriate for H Block devices. Existing PCS handsets that operate at the +23 dBm transmit power level comply with this limit by a large margin; or by about 20 dB on average, or by 16 dB in the worst case. In addition, in its ex-parte filing in this proceeding, Agilent stated that "it can produce a narrow-band duplexer covering G & H blocks that would allow a handset to meet -76 dBm OOBE as per TIA-98-F." For these reasons, the OOBE limit of -76 dBm/MHz is not unreasonable for PCS H-Block mobile devices.

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[42] Compliance with this limit should use test equipment with an average detector function, and be referenced to the H-Block device antenna RF terminal. It is assumed that the antenna gain of the H-Block device is 0 dBi, and the radiated OOBE will also be -76 dBm/MHz.

[43] Computed as -76 dBm/MHz – 38 dB for 1 meter – 3 dB head/body loss = -117 dBm/MHz at the victim PCS handset.

[44] For H-Block devices operating at 0.5 meters away, an OOBE limit of -82 dBm/MHz is needed to protect existing CDMA handsets. The 0.5 meter separation case uses the path loss at 1900 MHz, which is 32 dB, rather than the 1 meter loss of 38 dB. This is a difference of 6 dB. The highest OOBE from a CDMA handsets tested was -92 dBm/MHz, which allows interference-free operation for these existing PCS handsets to within 9 inches apart.

5 Impact of H Block & Potential for Interference

5.1 Impact of Insufficient Separation Distance from H-Block Devices

5.1.1 Impact to PCS Subscribers

The impact to existing PCS subscriber units from the interference caused by H-Block mobiles will manifest itself in a number of different ways. Most significant and detrimental will be the effect of creating gaps in service in and around the H Block mobiles, in some cases as much as 8 meters or 26 feet, if the FCC's proposed transmit power limit of +23 dBm is applied. The PCS mobile subscribers will not know the cause of the interference, and will simply assume it's due to insufficient receiver signal strength from the system. At these times, the PCS subscriber will believe there are in a dead zone, or no service zone, when actually the system have been otherwise operate normally without a nearby H-Block mobile transmitter disrupting its received signal margin. At these times, the victim PCS subscriber can experience an inability to make and receive calls, the inability to maintain calls being placed on the system, lost or drop calls, distorted or intermittent audio, and failure to properly hand-off. In addition, the PCS subscribers may not be able to determine location (E911 - Handset Based Technologies) as well as lowering the downlink data rates in wireless data connections. This all occurs, because the PCS mobile's receiver captures too much power and the receiver is "de-sensed" by the overload of power or IM from the nearby H-Block mobile. This happens because the existing handset's receive filters were never designed to reject signals that are so close to its receive band, and the H Block mobile transmit band is literally in the upper part of the receive filter skirt of PCS mobile receivers. Again, the "source" of the poor system performance would not be apparent to the PCS subscribers themselves, only that their mobile is not working. Also, they may also notice that another nearby phone call continues to operate, which happens to be on the H-block provider's system.

5.1.2 Impact to PCS Networks: Capacity Loss, Coverage Loss

The potential for mobile-to-mobile interference from the nearby H Block transmitters will impact PCS networks as a whole. As PCS subscribers encounter interference from the H-Block mobiles, the mobiles will experience elevated noise floors and increasing FER in low signal areas. In these low signal areas, the base station would normally be already transmitting at maximum power, and would not be able to increase it further. Besides degrading the forward link, the PCS subscriber units are required to perform measurements for the base station, and this can result in failure to process handoffs and dropped calls. If there is reserve base station power that is capable of improving the received signal level at the victim, this is done at the expense to other mobiles in the sector, which would have to compensate and increase power to all mobiles in the sector, otherwise the system would suffer performance degradations to all other mobiles in the same cell site. This also results in reduced system capacity in these cases, particularly when nearby cell sites also increase power to overcome the additional level required to overcome the H Block interference to a victim phone in a low signal area. This also results in reduced coverage in the fringe areas of the cell site, and indoors.

5.2 Sparse Deployments Result in H-Block Devices Transmitting at Higher Power

H-Block systems may be deployed initially with fewer base stations than the existing PCS systems operate with today. In addition, after initial deployments, the H Block base stations may also be sparsely deployed should operators decide to not fully build out their systems. Consequently, in these situations with sparse base station deployment, the H-Block mobiles can be expected to operate closer to maximum power level than typical handsets operate at today. At the same time, the mature PCS systems are operating with lower power levels to increase the capacity and efficiency of the systems deployed. These two effects will result in many cases of H Block mobiles transmitting at high levels and impacting PCS subscribers that need to receive low signals in many areas indoors, in-vehicles, and in rural areas.

5.3 Newer Wireless Technologies Transmit at Maximum Power

In some cases, the newer wireless technologies including 3G-EVDO, GSM EDGE, OFDM technologies transmit at the maximum power levels to achieve higher signal margins and optimize the transmission path. Data rate control, rather than Transmit Power Control (TPC), is used to control emissions in some cases. Voice-over-IP (VoIP) systems that utilize data systems for voice applications, and can have mobiles transmitting at their maximum power levels. Wireless data connections for the forward link, and in some cases for the reverse link, will operate at the maximum power level. Therefore, when an H-Block provider deploys these newer system technologies, their mobiles may be transmitting at its maximum power level in many locations.

5.4 Areas Most Susceptible to H-Block Interference

The areas most susceptible to interference from H Block devices is when these devices are in the low signal areas, when the victim call does not have enough signal margin to overcome the increased noise levels created by an nearby H Block device. These low signal areas will primarily occur indoors, or in-vehicles, or in rural areas. The indoor locations represent the areas where crowded people tend to use the PCS phones the most, and at the same time receive low signals and transmit at highest power levels, due to the higher penetration (attenuation) losses associated with in-buildings use.

These indoor areas include: airport terminals, bus terminals, train stations, hotel lobbies and conference rooms, office buildings, public locations, theater lobbies, shopping malls, stadiums, arenas, restaurants, convention centers, concerts, etc. The in-vehicle cases include: trains, buses, airplanes (grounded), passenger cars, etc. With the penetration losses of in-building and in-vehicle uses, the existing PCS phones are receiving lower signal levels, and the H-block devices would be transmitting at higher power levels to overcome the penetration losses.

At certain times, PCS subscribers are in a fixed location within a building or vehicle. In these cases (i.e. on a train, bus or airplane) the victim user may be assigned a seat or location that is in very close quarters with other mobile phone users. Depending upon the configuration of the vehicle, a mobile subscriber may be within one meter of six to eight other mobile subscribers (based upon typical seating layouts on the buses, trains or airplanes). Considering the average seat width of 19-20 inches, the mobile device may as close as 10 inches from another mobile device in the adjacent seat, or up to 1 meter away from a mobile user across an aisle, two seats away horizontally, or in a row of seating in from of behind a user. In a common seating layout for seating on a train, up to 8 victim users can experience interference from one H Block device transmitting 1 meter away. Also, it can be observed for the same one meter separation, that multiple H-Block devices have the potential to interfere with a victim PCS handset. In this case, the interference from multiple H-Block devices would add considerably (i.e. twice as much power from two users on H-Block calls) to the level received by the victim PCS subscriber.

Many PCS phone subscribers use headsets with their wireless phones. Users are growing accustomed to using headsets in a variety of locations, allowing users more freedom when using their PCS phones. For example, headsets are widely used by mobile users while on trains and sitting at airports, with the phones sitting on tray tables, on a user's lap, or on a belt clip. Further, in many states laws require the use of headsets while driving. The net result for these in-vehicle mobile phone users is that the handset will be lowered below the window level (i.e. laying phone on the seat, cup holder, or floor), and the subscriber unit experiences increased penetration losses from the vehicle. In these cases, the vehicle penetration losses will be approximately 10 dB (i.e. 10 dB below on-street signal strengths). These penetration losses are equivalent to some indoor locations. Therefore, in-vehicle cases can be as susceptible to H-block interference as some in-building locations, and can experience receiver de-sense by nearby H-Block mobiles.

5.5 How Often Does This Have To Happen To Cause a Subscriber to Switch?

The wireless industry is a very competitive industry, with multiple service providers competing for users in all markets across the country. In this competitive industry of wireless communications, having successful calls in crowded and heavily indoor trafficked locations is considered a litmus test of how good a carrier's service is. The same goes for providing successful calls in difficult to serve locations. Wireless subscribers also share and compare their service and coverage experiences. This is especially true when a subscriber is having problems in a specific area or venue, and can see that another person next to them is not having the same problem. If the H Block system works when others don't -- customer come to realize this, and may decide to switch to the system that works in all locations.

It will not take many dropped calls, to cause customers to switch providers. After customers experience problems with their service, especially if it repeats itself, they are more inclined to look elsewhere for service. They look to see of other mobiles are experiencing the same problems, and they ask others questions (including friends and business associates) about the reliability of their wireless phone service. In the worst case scenario described above, the PCS subscribers will find out that they are having problem in high traffic venues and the H-Block subscribers are seeing no problems. When the time comes for contract renewal, particularly in light of the ease of maintaining phone numbers with LNP, the decision to switch providers is simpler and less painful for subscribers. Also, when the pricing models are similar for various providers' service, the determining factor will be the quality of the service or goods delivered. In addition, the typical customers using their phones in close proximity are the high usage and business customers. These customers expect their service to be as good as possible; their business depends upon it. Reliable wireless service is critical for these users, and they represent the highest valued customers for wireless providers. Further, for our nations First Responders this need for reliable wireless service in all locations is even more important, and they make decisions based upon the reliability that the wireless system has to offer. In addition, wireless data users that require high-speed data connections will not prefer providers that experience much lower performance in low signal areas.

5.6 Low Signal Areas Occur Often in PCS Networks

Low signal areas occur frequently in PCS networks. They occur in the outer regions of the cell coverage areas, and in buildings and vehicles within the cell coverage area. These lower signal areas tend to occur more often in PCS networks for the following reasons. Four factors are highlighted below.

1. Propagation Factor -- Radio propagation reduces the received signal levels exponentially with increasing distance.[45] This means that signals will decrease rapidly at closer distances, and much slower at farther distances, resulting in a larger percent of calls in the outer regions of a cell site.
2. Geometry Factor -- The second factor is due to geometry of the outer regions of a cell coverage area (i.e. lower signal levels), which represents the larger regions. These regions are exponentially larger than the inner regions with higher signal levels.[46]
3. Path Loss Factor -- The propagation losses of PCS 1900 MHz signal propagation is about 7 to 12 dB more loss than with cellular 800 MHz systems.[47] With PCS and cellular systems collocating cell sites, the PCS networks will experience more areas with lower signal strengths.
4. In-Building Factor -- A significant and growing amount of wireless calls are made in buildings and vehicles, which reduces the received signal level as compared to outdoor locations. Typical building penetration losses are 10 to 30 dB,[48] and typical vehicle penetration losses are 10 to 25 dB depending on the vehicle.[49] The penetration loss of 10 to

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[45] For example, the propagation loss is an urban environment is about 40 dB/decade, or the signal will decrease with the radius to the 4th power.

[46] The area of a circle is proportionate to the radius to the 2nd power. Therefore, lower signal areas further away from cell sites (having larger radius') will have exponentially larger areas to the 2nd power.

[47] For example, the additional propagation loss in a suburban environment (i.e. 30 dB/decade) for PCS frequencies is equal to 10 dB (i.e. 30 x Log (1900/880) = 10 dB), as compared to cellular frequencies.

[48] Building penetration losses depend on a variety of factors including the building material structure, size of windows, direction of closest cell site, interior room with no windows, additional partitions, etc.

[49] Penetration losses for vehicles will depend on a couple of factors. For cars and buses the signal penetration loss is typically 10 dB when using headsets (with the phone below the window level), and its typically 5 dB when held at the head of a user. For trains and airplanes the penetration loss is usually 10 to 25 dB, and depends on the size and proximity of windows to the users. These losses are

15 dB for in-buildings areas (and in-vehicles) are very common, and will effectively reduce an outdoor signal of -90 dBm to a received level of -100 to -105 dBm inside the building or vehicle. Also, a penetration loss of 20 dB reduces an outdoor signal of -80 dBm (a strong signal, not at the cell edge) to a -100 dBm level inside. In this case, the call will perform as though it is operating at the edge of the cell site (i.e. from a link budget standpoint), even though it is well within the coverage area of the cell site.

The combination of these four factors results in a significantly larger percentage of calls in the lower signal areas, as compared to calls in areas with higher signal levels.

To illustrate these factors and quantify a percentage (calls in the lower signal areas), we analyzed the following case for indoor wireless users. In this simplified indoor example, we analyzed the received signal levels of mobile phones in 5 dB increments, and computed the coverage area for each signal range. In this case, we assumed the coverage radius of a PCS cell site is 2 miles,[50] for the received signal level of -105 dBm. In this case, the -100 dBm to -105 dBm signal range is representative of in-building received signal levels when the outdoor signals level is -90 dBm, and building penetration losses are 10 to 15 dB.[51] Using a suburban propagation loss factor and the area of a circle, the area for each 5 dB signal range is calculated and provided in the table below.

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comparable to in-building penetration losses, and reduce the signals inside these vehicles considerably. In addition, since vehicles travel through poor coverage areas at ground level they have a greater likelihood to receive signals at lower signals levels.

[50] The results will be independent of the coverage radius used in this analysis. In this case, we selected a coverage radius of 2 miles for a PCS suburban cell site. The propagation loss factor of 32 dB/decade is used. For urban areas 40 dB/decade can be substituted, and for rural areas use 27 to 30 dB/decade.

[51] For outdoor PCS phone users the coverage area would extend beyond the -90 dBm signal range (which is -100 to -105 dBm indoors), however in this example we will only consider the coverage area for in-building users, which is to the received signal level of -105 dBm indoors.

Table 12 Percentage of Lower Signal Areas Occurring Indoors

Mobile RSSI Level (dBm)	Distance from PCS Cell Site (miles)	Cell Coverage Area (sq-mi)	Coverage Area from RSSI to RSSI-5 dB (sq-mi)	Percent of Cell Coverage Area (% of Total)	Mobile RSSI Range for Coverage Area
-105	2.00	12.6			
-100	1.40	6.1	6.4	51%	-100 to -105 dBm
-95	0.97	3.0	3.1	25%	-95 to -100 dBm
-90	0.68	1.5	1.5	12%	-90 to -95 dBm
-85	0.47	0.7	0.7	6%	-85 to -90 dBm
-80	0.33	0.3	0.4	3%	-80 to -85 dBm

As indicated in the table above, the percentage of calls in each 5 dB range doubles with lower signal strength. For example, signals in the -95 to -100 dBm range are twice as likely to occur as calls in the -90 to -95 dBm range, and calls in the -100 to -105 dBm range are twice as likely to occur as calls in the -95 to -100 dBm range. The -100 to -105 dBm signal range is representative of users inside building on lower floors, or within vehicles at the outer regions of the cell coverage area, or outdoors in some rural markets having larger cell coverage areas.[52]

This illustrates the impact of cell geometry and radio propagation, which contributes to significantly more areas with lower signal strengths than areas with higher signal strengths. The cell coverage area of the lowest 5 dB signal range represents approximately half of the cell coverage area. This simple example demonstrates that lower signal area more likely to occur than higher signal areas (due to basic geometry and propagation factors).

[52] When users are outdoors within suburban and urban markets the signals from adjacent cell sites will increase the mobile received signal strength before reaching the -105 dBm level. In these outdoor locations, the percentage of calls in the -100 to -105 dBm range will decrease considerably, however they can still occur in many outdoor locations, i.e. poor coverage areas, difficult site zoning areas, areas with heavy tree/foliage attenuation, urban clutter, and areas with farther cell spacing.

Appendix A – Company Information & Biographies

V-COMM is a leading provider of quality engineering and engineering related services to the worldwide wireless telecommunications industry. V-COMM's staff of engineers are experienced in Cellular, Personal Communications Services (PCS), Enhanced Specialized Mobile Radio (ESMR), Paging, Wireless Data, Microwave, Signaling System 7, and Local Exchange Switching Networks. We have provided our expertise to wireless operators in engineering, system design, implementation, performance, optimization, and evaluation of new wireless technologies. Further, V-COMM was selected by the FCC & Department of Justice to provide expert analysis and testimony in the NextWave and Pocket Communications Bankruptcy cases. V-COMM has offices in Blue Bell, PA and Cranbury, NJ and provides services to both domestic and international markets. For additional information, please visit V-COMM's web site at www.vcomm-eng.com.

BIOGRAPHIES OF SENIOR MEMBERS OF V-COMM, L.L.C.

Dominic C. Villecco
President and Founder

Dominic Villecco, President and founder of V-COMM, is a pioneer in wireless telecommunications engineering, with 22 years of executive-level experience and various engineering management positions. Under his leadership, V-COMM has grown from a start-up venture in 1996 to a highly respected full-service consulting telecommunications engineering firm.

In managing V-COMM's growth, Mr. Villecco has overseen expansion of the company's portfolio of consulting services, which today include a full range of RF & Network design, engineering & support; network design tools; measurement hardware; and software services; as well as time-critical engineering-related services such as business planning, zoning hearing expert witness testimony, regulatory advisory assistance, and project management.

Before forming V-COMM, Mr. Villecco spent 10 years with Comcast Corporation, where he held management positions of increasing responsibility, his last being Vice President of Wireless Engineering for Comcast International Holdings, Inc. Focusing on the international marketplace, Mr. Villecco helped develop various technical and business requirements for directing Comcast's worldwide wireless venture utilizing current and emerging technologies (GSM, PCN, ESMR, paging, etc.).

Previously he was Vice President of Engineering and Operations for Comcast Cellular Communications, Inc. His responsibilities included overall system design, construction and operation, capital budget preparation and execution, interconnection negotiations, vendor contract negotiations, major account interface, new product implementation, and cellular market acquisition. Following Comcast's acquisition of Metrophone, Mr. Villecco successfully merged the two technical departments and managed the combined department of 140 engineers and support personnel.

Mr. Villecco served as Director of Engineering for American Cellular Network Corporation (AMCELL), where he managed all system implementation and engineering design issues. He was responsible for activating the first cellular system in the world utilizing proprietary automatic call delivery software between independent carriers in Wilmington, Delaware. He also had responsibility for filing all FCC and FAA applications for AMCELL before it was acquired by Comcast.

Prior to joining AMCELL, Mr. Villecco worked as a staff engineer at Sherman and Beverage (S&B), a broadcast consulting firm. He designed FM radio station broadcasting systems and studio-transmitter link systems, performed AM field studies and interference analysis and TV interference analysis, and helped build a sophisticated six-tower arrangement for a AM antenna phasing system. He also designed and wrote software to perform FM radio station allocations pursuant to FCC Rules Part 73.

Mr. Villecco started his career in telecommunications engineering as a wireless engineering consultant at Jubon Engineering, where he was responsible for the design of cellular systems, both domestic and international, radio paging systems, microwave radio systems, two-way radio systems, microwave multipoint distribution systems, and simulcast radio link systems, including the drafting of all FCC and FAA applications for these systems.

Mr. Villecco has a BSEE from Drexel University, in Philadelphia, and is an active member of IEEE. Mr. Villecco also serves as an active member of the Advisory Council to the Drexel University Electrical and Computer Engineering (ECE) Department.

Relevant Expert Witness Testimony Experience:

Over the past five years, Mr. Villecco had been previously qualified and provided expert witness testimony in the states of New Jersey, Pennsylvania, Delaware and Michigan. Mr. Villecco has also provided expert witness testimony in the following cases:

- United States Bankruptcy Court

- NextWave Personal Communications, Inc. vs. Federal Communications Commission (FCC) **

- Pocket Communications, Inc. vs. Federal Communications Commission (FCC) **

** In these cases, Mr. Villecco was retained by the FCC and the Department of Justice as a technical expert on their behalf, pertaining to matters of wireless network design, optimization and operation.

David K. Stern
Vice President and Co-Founder

David Stern, Vice President and co-founder of V-COMM, has over 20 years of hands-on operational and business experience in telecommunications engineering. He began his career with Motorola, where he developed an in-depth knowledge of wireless engineering and all the latest technologies such as CDMA, TDMA, and GSM, as well as AMPS and Nextel's iDEN.

While at V-COMM, Mr. Stern oversaw the design and implementation of several major Wireless markets in the Northeast United States, including Omnipoint - New York, Verizon Wireless, Unitel Cellular, Alabama Wireless, PCS One and Conestoga Wireless. In his position as Vice President, he has testified at a number of Zoning and Planning Boards in Pennsylvania, New Jersey and Michigan.

Prior to joining V-COMM, Mr. Stern spent seven years with Comcast Cellular Communications, Inc., where he held several engineering management positions. As Director of Strategic Projects, he was responsible for all technical aspects of Comcast's wireless data business, including implementation of the CDPD Cellular Packet Data network. He also was responsible for bringing into commercial service the Cellular Data Gateway, a circuit switched data solution.

Also, Mr. Stern was the Director of Wireless System Engineering, charged with evaluating new digital technologies, including TDMA and CDMA, for possible adoption. He represented Comcast on several industry committees pertaining to CDMA digital cellular technology and served on the Technology Committee of a wireless company on behalf of Comcast. He helped to direct Comcast's participation in the A- and B-block PCS auctions and won high praise for his recommendations regarding the company's technology deployment in the PCS markets.

At the beginning of his tenure with Comcast, Mr. Stern was Director of Engineering at Comcast, managing a staff of 40 technical personnel. He had overall responsibility for a network that included 250 cell sites, three MTSOs, four Motorola EMX-2500 switches, IS-41 connections, SS-7 interconnection to NACN, and a fiber optic and microwave "disaster-resistant" interconnect network.

Mr. Stern began his career at Motorola as a Cellular Systems Engineer, where he developed his skills in RF engineering, frequency planning, and site acquisition activities. His promotion to Program Manager-Northeast for the rapidly growing New York, New Jersey, and Philadelphia markets gave him the responsibility for coordinating all activities and communications with Motorola's cellular infrastructure customers. He directed contract preparations, equipment orders and deliveries, project implementation schedules, and engineering support services.

Mr. Stern earned a BSEE from the University of Illinois, in Urbana, and is a member of IEEE.

Sean Haynberg
Director of RF Technologies

Sean Haynberg, Director of RF Technologies at V-COMM, has over 15 years of experience in wireless engineering. Mr. Haynberg has extensive experience in wireless system design, implementation, testing and optimization for wireless systems utilizing CDMA, TDMA, GSM, AMPS and NAMPS wireless technologies. In his career, he has conducted numerous first office applications, compatibility & interference studies, and new technology evaluations to assess, develop and integrate new technologies that meet industry and FCC guidelines. His career began with Bell Atlantic NYNEX Mobile, where he developed an in-depth knowledge of wireless engineering.

While at V-COMM, Mr. Haynberg was responsible for the performance of RF engineering team supplying total RF services to a diverse client group. Projects varied from managing a team of RF Engineers to design and implement new a PCS wireless network in the NY MTA; to the wireless system design & expansion of international markets in Brazil and Bermuda; to system performance testing and optimization for numerous markets in the north and southeast; to the development and procurement of hardware and software engineering tools; to special technology evaluations, system compatibility and interference testing. He has also developed tools and procedures to assist carriers in meeting compliance with FCC rules & regulations for RF Safety, and other FCC regulatory issues. In addition, Mr. Haynberg was instrumental in providing leadership, technical analysis, engineering expertise, and management of a team of RF Engineers to deliver expert-level engineering analysis & reporting on behalf of the FCC & Department of Justice, in the NextWave and Pocket Communications Bankruptcy proceedings.

Prior to joining V-COMM, Mr. Haynberg held various management and engineering positions at Bell Atlantic NYNEX Mobile (BANM). He was responsible for evaluating new technologies and providing support for the development, integration and implementation of first office applications (FOA), including CDMA, CDPD, and RF Fingerprinting Technology. Beyond this, Haynberg provided RF engineering guidelines and recommendations to the company's regional network operations, supported the deployment and integration of new wireless equipment and technologies, including indoor wireless PBX/office systems, phased/narrow-array smart antenna systems, interference and inter-modulation analysis and measurement, and cell site co-location and acceptance procedures. He was responsible for the procurement, development and support of engineering tools for RF, network and system performance engineers to enhance the system performance, network design and optimization of the regional cellular networks. He began his career as an RF Engineer responsible for the system design and expansion of over 100 cell sites for the cellular markets in New Jersey, Philadelphia, PA; Pittsburgh, PA; Washington, DC; and Baltimore, MD market areas.

Mr. Haynberg earned a Bachelor of Science degree in Electrical Engineering with high honors, and attended post-graduate work, at Rutgers University in Piscataway, New Jersey. While at Rutgers, Mr. Haynberg received numerous honors including membership in the National Engineering Honor Societies Tau Beta Pi and Eta Kappa Nu. In addition, Mr. Haynberg has qualified and provided expert witness testimony in the subject matter of RF engineering and the operation of wireless network systems for many municipalities in the State of New Jersey.